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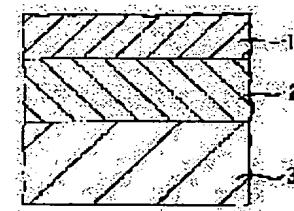
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(54) OPTICAL RECORDING MEDIUM

(57)Abstract:

PURPOSE: To increase the recording density of an optical recording medium.

CONSTITUTION: A layer 2 contg. at least a saturable absorbing dye is disposed on the pattern forming surface of a transparent substrate 1 with a formed recording pattern. The molecular extinction coefft. ε of the dye at the wavelength of light for reproduction is regulated to $\geq 10^4$ and the relaxation time τ regulated to 1–100ns. A reflecting layer 3 having $\geq 70\%$ reflectance at the interface between the layer 3 and the air may further be disposed on the layer 2. The thickness of the layer 2 may be regulated so as to minimize the intensity of reflected light due to interference to the intensity of light for reproduction and a naphthalocyanine dye may be used as the dye in the layer 2.



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CLAIMS

[Claim(s)]

[Claim 1]A recording pattern recorded as unevenness or change of an optical property on a transparent substrate corresponding to an information signal, In an optical recording medium for detecting by change of reflection of regenerated light which carries out vertical incidence from the transparent substrate side, and carries out a move scan relatively to a transparent substrate, and reproducing a signal, The molar extinction coefficient [in / it has further a layer which contains saturable absorption coloring matter at least on a recording pattern, and / wavelength of regenerated light of this saturable absorption coloring matter] epsilon is $10^4 \leq \epsilon$. An optical recording medium which exists and is characterized by the relaxation time τ being 1 second $\leq \tau \leq 100\text{ns}$.

[Claim 2]The optical recording medium according to claim 1 with which reflectance in a transparent substrate, a saturable absorption coloring matter contained layer, and an air interface is characterized by providing not less than 70% of reflection film one by one.

[Claim 3]The optical recording medium according to claim 1, wherein thickness of a saturable absorption coloring matter contained layer is the thickness which makes reflected light intensity by interference the approximately minimum to light intensity of regenerated light.

[Claim 4]The optical recording medium according to claim 1, 2, or 3, wherein saturable absorption coloring matter is naphthalocyanine system coloring matter.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the optical recording medium for irradiating with regenerated light from the substrate side, detecting the recording pattern by the unevenness corresponding to the information signal beforehand recorded on the transparent substrate, or change of an optical property by change of reflection of a reproduction light beam, and reproducing a signal.

[0002]

[Description of the Prior Art] In recent years, in the field of information storage, research on an optical information recording method is advanced by every place. Compared with a magnetic recording system, single or more figures can attain [that this optical information recording method can perform record and reproduction by non-contact,] high storage density. It has many advantages of being able to respond to an only for [reproduction] type, the added type of a postscript, and each memory gestalt of rewritable type, and the use broad from industrial use to a noncommercial use as a form which enables realization of a cheap large capacity file is considered.

[0003] As an only for [playback] type optical recording medium, a digital audio disc (what is called a compact disk), an optical video disk (what is called a laser disc), or CD-ROM has already spread widely among above-mentioned memory gestalten. Let these optical recording media be the structures which generally formed the reflection film which consists of metal thin films, such as an Al film, on the transparent substrate in which the recording pattern by the unevenness corresponding to an information signal or change of an optical property was formed.

From the transparent substrate side, it irradiates with regenerated light, such as a laser beam, the strength of the catoptric light is detected, and information is reproduced.

[0004]

[Problem(s) to be Solved by the Invention] In the above only for [reproduction] type optical recording media, in order to correspond to digitization of VTR, a high definition television (HDTV), etc., the further improvement in storage density is called for. The miniaturization of the size of

an optical recording medium is called for from operational convenience, and the further improvement in storage density is called for also from this.

[0005]Although it is possible to carry out minuteness making of the recording pattern according to the information formed in an optical recording medium as a method of raising the storage density of such an optical recording medium, Since the spot diameter of the regenerated light which reproduces this has a diffraction limit, it will become impossible to reproduce this recording pattern, if minuteness making of the recording pattern is carried out not much.

[0006]Then, means, such as short wavelength formation of regenerated light, compression-izing of a signal code, and a raise in NA of an optical system, are examined, and super resolution attracts attention as a leading means also in it.

[0007]The above-mentioned super resolution makes it a principle to make the spot diameter of irradiation light smaller than a diffraction limit, and to raise resolution by providing an aperture smaller than the diffraction limit of irradiation light in an object point position. (Reference: "J.of Optical) [Charles W.McCutchen, "Superresolution in Microscopy and the Abbe Resolution Limit,] Society of America, 57 (10), 1190(1967).Tony Wilson and Colin Sheppard, "Theory and Practice of Scanning Optical Microscopy", Academic Press (London), 1984

[0008]In order to apply such super resolution to an optical recording medium, the aperture needs to move with movement on the optical recording medium of regenerated light. Then, the method of using the material of an optical response for a reflection film, as shown in JP,2-96926,A is proposed. An aperture smaller than the diffraction limit of regenerated light is made to form in a reflection film by using the material of an optical response for a reflection film during the above-mentioned invention, Making small the spot diameter of catoptric light reflected by the reflection film, and raising the resolution is proposed, The non-linear optical material from which an optical property changes with regenerated light directly as a material of an optical response, or the phase change material from which an optical property changes with the thermogeneration by absorption of regenerated light is mentioned. However, a concrete material which is suitable during the above-mentioned invention at this is not illustrated, but the embodiment nature is low. In JP,1-143041,A and JP,1-143042,A in advance of this patent, Make thermally the field where a magnetic Kerr effect shows up in a magneto-optical recording playback system narrower than the spot diameter of regenerated light, the super resolution effect is made to reveal, and having attained high density recording reproduction is reported.

[0009]Then, an object of this invention is to provide the optical recording medium for making it possible to reproduce the information on the high recording density by the recording pattern by which minuteness making was carried out rather than the diffraction limit of regenerated light by super resolution.

[0010]

[Means for Solving the Problem]In order to attain the above-mentioned purpose, as a result of this invention person's etc. inquiring wholeheartedly, saturable absorption coloring matter was used as a material of an optical response, and it found out that a super resolution phenomenon was realizable according to absorption saturation phenomena at the time of an optical exposure of this saturable absorption coloring matter.

[0011]Namely, a recording pattern in which this invention was recorded as unevenness or change of an optical property on a transparent substrate corresponding to an information signal, In an optical recording medium for detecting by change of reflection of regenerated light which carries out vertical incidence from the transparent substrate side, and carries out a move scan relatively to a transparent substrate, and reproducing a signal, The molar extinction coefficient [in / it has further a layer which contains saturable absorption coloring matter at least on a recording pattern, and / wavelength of regenerated light of said saturable absorption coloring matter] epsilon is $10^4 \leq \epsilon \leq 10^5$. It is and is characterized by the relaxation time tau being 1 second $\leq \tau \leq 100$ ns.

[0012]This invention is good in such an optical recording medium also as thickness to which reflectance in a transparent substrate, a saturable absorption coloring matter contained layer, and an air interface may provide not less than 70% of reflection film one by one, and makes the approximately minimum further reflected light intensity according thickness of a saturable

absorption coloring matter contained layer to interference to light intensity of regenerated light. [0013] In an optical recording medium of this invention, it is good also considering saturable absorption coloring matter as naphthalocyanine system coloring matter further again.

[0014] An aperture smaller than a diffraction limit of regenerated light is formed by irradiating a saturable absorption coloring matter contained layer with regenerated light, and changing a complex index of refraction of the minimum portion of this saturable absorption coloring matter contained layer in an optical recording medium of this invention, Catoptic light which has a spot diameter smaller than a diffraction limit is obtained, and a super resolution phenomenon is realized. Under the present circumstances, saturable absorption coloring matter in a saturable absorption coloring matter contained layer will be in an excitation state to which a complex index of refraction changed with absorption of regenerated light from a ground state, forms an aperture, and returns to a ground state through the relaxation time tau. Therefore, sufficient sensitivity is not obtained when reflected light intensity according thickness of a saturable absorption coloring matter contained layer to interference to light intensity of regenerated light as the molar extinction coefficient epsilon in wavelength of regenerated light of saturable absorption coloring matter used is $\epsilon < 10^4$ is made into thickness made into the approximately minimum. If the relaxation time tau in wavelength of regenerated light of saturable absorption coloring matter is $\tau < 1$ ns, Sensitivity with it cannot be obtained, but since aperture formation time is long, shape of an aperture can become being 100 second $< \tau$ with an ellipse form long to a scanning direction of regenerated light, and resolution cannot be raised. [short aperture formation time and] [sufficient] A higher effect is acquired by setting relaxation time tau to 1 s - 10 ns.

[0015] As saturable absorption coloring matter, since a laser beam is used as regenerated light in many cases, what has absorption strong against a laser wavelength region (750-810 nm) is preferred, and a stable thing is still more nearly thermally and photochemically preferred. As such saturable absorption coloring matter, a cyanine system, a phthalocyanine system, and a naphthalocyanine system are mentioned, for example, DTTC made from EXCITON (United States), HITC, IR-125, IR-140, and IR-144 grade are mentioned. Especially naphthalocyanine system coloring matter is preferred from a point of having a big molar extinction coefficient and high optical stability.

[0016]

[Function] This invention the recording pattern recorded as unevenness or change of an optical property on the transparent substrate corresponding to the information signal, In the optical recording medium for detecting by change of the reflection of regenerated light which carries out vertical incidence from the transparent substrate side, and carries out a move scan relatively to a transparent substrate, and reproducing a signal, It has further a layer which contains saturable absorption coloring matter at least on a recording pattern, and the molar extinction coefficient epsilon in the wavelength of the regenerated light of said saturable absorption coloring matter is $10^4 < \epsilon$.

Since the relaxation time tau is 1 second $\leq \tau \leq 100$ ns, it is possible to take out the catoptic light of a spot diameter smaller than the diffraction limit of regenerated light, and it is possible to reproduce the recording pattern by which minuteness making was carried out rather than the diffraction limit of regenerated light.

[0017]

[Example] Although the concrete example which applied this invention is hereafter described based on an experimental result, it precedes describing an example and theoretical explanation is given about the super resolution effect by a saturable absorption phenomenon. Namely, the saturable absorption phenomenon of the saturable absorption coloring matter contained layer in the optical recording medium with which a saturable absorption coloring matter contained layer and a reflection film are formed one by one on a transparent substrate is searched for from a simple speed equation, The transmissivity to the reflection film of regenerated light was computed, and it asked for distribution of the reflectance as an optical recording medium in the

state where regenerated light is moving in the optical-recording-medium top, and the beam profile of catoptric light. First, although it is a speed equation of the saturable absorption of a saturable absorption coloring matter contained layer, Saturable absorption coloring matter will be from a ground state in an excitation state by the absorption of light, and shall return to a ground state through the relaxation time tau. It thinks with an unit area (cm^{-2}), and change of the molecularity G of a ground state is expressed like several 1 as all the molecularity N, the absorptivity A, the regenerated light intensity I, the regenerated light wavelength lambda, the velocity of light c, and Planck constant h. The above-mentioned saturable dye shall not absorb light at all in an excitation state.

[0018]

[Equation 1]

$$\frac{dG(t)}{dt} = -\frac{\lambda I A}{h c} + \frac{N - G(t)}{\tau}$$

[0019]The above-mentioned absorptivity A is determined by the extinction coefficient k of a saturable absorption coloring matter contained layer (complex-index-of-refraction imaginary component), a membranous structure and thickness, and the optical constant at this time. The above-mentioned extinction coefficient k is expressed by the molecularity G, the thickness d, and the molar extinction coefficient epsilon of coloring matter like several 2. (Several 2 inside N_A expresses the Avogadro's number.)

[0020]

[Equation 2]

$$k = \frac{2.303 \epsilon \lambda G}{4 \pi N_A d}$$

[0021]Next, it asked for the relation between the above-mentioned absorptivity A and the extinction coefficient k by multilayer film reflectivity calculation. That is, in the multilayer film system as shown in drawing 1, it asked from the formula in the regular-reflection conditions over a multilayer film with the structure of these films, thickness, and a complex index of refraction. In the above-mentioned multilayer film, when thickness of each class is made into d_j and a complex index of refraction is made into n_j^c ($= n_j - ik_j$), the reflectance R, the transmissivity T, and the absorptivity A are expressed like a three number, several 4, and several 5, respectively.

[0022]

[Equation 3]

$$R = \left| \frac{a_{21}}{a_{11}} \right|^2$$

[0023]

[Equation 4]

$$T = \left| \frac{1}{a_{11}} \right|^2 (n_m / n_1)$$

[0024]

[Equation 5]

$$A = 1 - R - T$$

[0025]At this time, a_{11} , a_{12} , a_{21} , a_{22} , t_j^{-1} , s_j , and δ_j are expressed like several 6, several 7, several 8, and several 9. At this time, a_{11} , a_{12} , a_{21} , and a_{22} . The permeability coefficient in the interface between j and the j+1st layers and s_j show (the reflection coefficient/permeability coefficient) in the interface, and, as for each ingredient of the propagation matrix of this multilayer film system, and t_j , δ_j shows the phase shift of the light in j layer order.

[0026]

[Equation 6]

$$\begin{bmatrix} a_{11}, a_{12} \\ a_{21}, a_{22} \end{bmatrix} = \begin{bmatrix} t_j^{-1}, s_j \\ s_j, t_j^{-1} \end{bmatrix} \prod_{i=2}^{m-1} \begin{bmatrix} t_j^{-1} \exp(i \delta_j), s_j \exp(i \delta_j) \\ s_j \exp(-i \delta_j), t_j^{-1} \exp(-i \delta_j) \end{bmatrix}$$

[0027]

[Equation 7]

$$t_j^{-1} = (n^e_j + n^e_{j+1}) / 2 n^e_j$$

[0028]

[Equation 8]

$$s_j = r_j / t_j = (n^e_j - n^e_{j+1}) / 2 n^e_j$$

[0029]

[Equation 9]

$$\delta_j = 2 \pi n^e_j d_j / \lambda$$

[0030] Thus, it asked for the relation between the absorptivity A and the extinction coefficient k. When the molecularity of the saturable absorption coloring matter of the ground state in a saturable absorption coloring matter contained layer changed, not only the imaginary part of a complex index of refraction but real part changed due to Kramers-Kronig, but coloring matter disregarded change of the real part refractive index by this calculation as what was distributed thin.

[0031] Then, it asked for the reflectance distribution of a actual optical recording medium, and the beam profile of catoptric light using the above formulas. That by which the saturable absorption coloring matter contained layer 2 which becomes rather than consisting of saturable absorption coloring matter and a binder was formed as an optical recording medium on the transparent substrate 1 which consists of glass as shown in drawing 2, and the reflection film 3 which vapor-deposits aluminum was formed on it was assumed. The complex indices of refraction of the transparent substrate and the reflection film were assumed to be 1.5-i0 and 1.9-i7, respectively. Reflectance is set to 0 when a saturable dye contained layer is an initial state (the output of regenerated light is 0). Or the thickness which makes reflected light intensity by interference the approximately minimum to the light intensity of regenerated light where the regenerated light of some output is irradiated, That is, the phase of the catoptric light from a saturable absorption coloring matter contained layer / transparent substrate interface and the catoptric light from a saturable absorption coloring matter contained layer / reflection film interface should fulfill the thickness used as the thing shifted 180 degrees, and what is called nonreflective conditions, and set the complex index of refraction to 1.7-i0.5, and thickness was assumed to be 1 nm.

[0032] In the above optical recording media, the molar extinction coefficient epsilon of saturable absorption coloring matter 5×10^5 , A calculation result when the rotational linear velocity v of the optical recording medium was assumed for the relaxation time tau for 5 ns, the laser beam was assumed for the spot diameter of 1.2 m/s and regenerated light as 2 micrometers and regenerated light, the wavelength is 780 nm and the output is 0.6 mW is shown in drawing 3. Although the initial reflectivity of this optical recording medium was 1.4%, when irradiated with the above regenerated light, it turned out that reflectance as shown by a figure inner substance line in the center of a spot of regenerated light rises even to 10%. The transmissivity to the reflection film of the regenerated light in the profile, i.e., above-mentioned optical recording medium, of the catoptric light shown by a figure middle point line serves as shape symmetrical with order to the optical-recording-medium running direction shown by the figure Nakaya seal M like the profile of the regenerated light shown with the dashed dotted line in a figure.

[0033] Next, although the result at the time of making rotational linear velocity v of an optical

recording medium into 30 m/s is shown in drawing 4. The profile of the catoptric light shown by a figure middle point line serves as shape symmetrical with order like [this] the result of drawing 3 to the optical-recording-medium running direction shown by the figure Nakaya seal M like the profile of the regenerated light shown with the dashed dotted line in a figure. The gap of the profile of regenerated light and the profile of catoptric light shown with the dashed dotted line in a figure is 2 ns as time, and is 0.06 micrometer as length. Therefore, in the above optical recording media, the influence which the rotational linear velocity of this optical recording medium has on the shape of the aperture formed in a saturable absorption coloring matter contained layer was small, and it turned out that the influence which it has on the profile of reflectance and catoptric light is small.

[0034]The result at the time of setting relaxation time tau to 100 ns is shown in drawing 5. The profile of the catoptric light shown by a figure middle point line shifts about 15 ns back to the optical-recording-medium running direction shown by the figure Nakaya seal M. This discrepancy increases in proportion to the relaxation time tau mostly. Therefore, it turned out that the relaxation time tau has big influence on the profile of reflectance and catoptric light. As shown in a figure, it shifts from a center, and it is order, and a jitter of become [the shape of beam / unsymmetrical] increases to a regenerative signal, and it causes the rise of an error rate.

[0035]Subsequently, it calculated by having changed the output of regenerated light, and the relation of the reflectance in a regenerated light output, a catoptric light spot diameter, and the center of a spot of regenerated light was investigated. A result is shown in drawing 6. The rate (a catoptric light spot diameter / regenerated light spot diameter) over a regenerated light spot diameter shows a catoptric light spot diameter. It turned out that the catoptric light spot diameter which the reflectance shown by O in a figure rises as are shown in drawing 6 and a regenerated light output is raised, and is shown by - in a figure also becomes large by SACHU ration.

[0036]Although the relation between the reflectance in the center of a spot of regenerated light and a catoptric light spot diameter is shown in drawing 7, In order to have obtained the catoptric light which has one half of the spot diameters of the diffraction limit of regenerated light in order to make a catoptric light spot diameter into about 50% of regenerated light spot diameters from the result of drawing 7 namely, it turned out that it is preferred to make reflectance in the center of a spot of regenerated light into 10 to 15%.

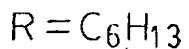
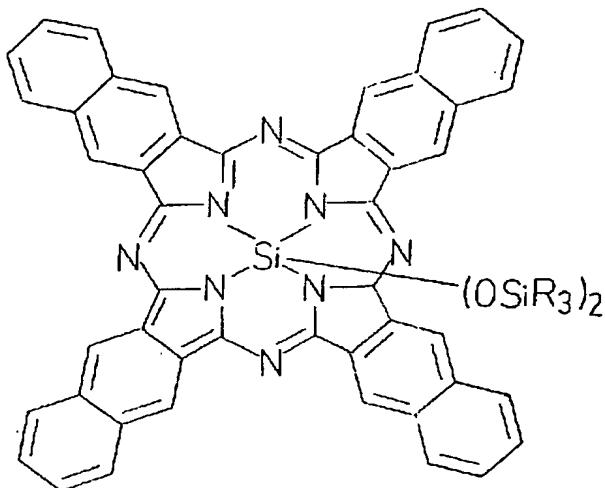
[0037]These theoretical-analyses result is a result when membranous lamination is ideal on the physical properties of coloring matter. Although it seems that establishment of material and manufacturing conditions can attain this ideal condition, Here, the example 2 of an experiment shows the experiment from which the super resolution effect was clearly revealed in the example 1 of an experiment although ideal conditions had shifted, and the signal was detected in change of the reflectance to the regenerated light output which is a phenomenon indispensable to the super resolution effect in a actual optical magnetic recording medium.

[0038]Example of an experiment In the example of 1 experiment, the optical recording medium was actually manufactured and the situation of change of the reflectance at the time of irradiating this optical recording medium with regenerated light was investigated. First, the complex index of refraction of the saturable absorption coloring matter contained layer was measured. Bis(*tri-n-hexyl siloxy*)silicon naphthalocyanine as shown in ** 1 as saturable absorption coloring matter (henceforth) SINC is called -- using -- as a binder -- the polymethylmethacrylate (henceforth) of the molecular weight 400,000 PMMA is called. It uses and these were dissolved in chloroform, on the glass substrate which is a transparent substrate, it applied with the spin coat method, thickness was changed to 100-200 nm, and the saturable absorption coloring matter contained layer was formed. The mixture ratio (weight ratio) of SINC, PMMA, and chloroform is 2:15:500.

PMMA performs stirring and heating over several hours, and SICN performed stirring by an ultrasonic cleaner and it made it dissolve it thoroughly in the case of these mixing.

[0039]

[Formula 1]



[0040] Thus, measurement of the transmissivity of the obtained saturable absorption coloring matter contained layer and reflectance was performed. A result is shown in drawing 8. O in a figure shows the transmissivity of this saturable absorption coloring matter contained layer of 170 nm of thickness, the transmissivity of the medium reflectance, a figure middle point line, and whose solid line of – in a figure are complex-index-of-refraction 1.7-i0.3, and reflectance. The transmissivity of the medium which is complex-index-of-refraction 1.7-i0.3 shown by the result, figure inner substance line, and dotted line which are shown by O in a figure and –, and which were surveyed, and reflectance are well in agreement, and it is judged that the complex index of refraction of the surveyed saturable absorption coloring matter contained layer is 1.7-i0.3 so that they may be known seeing these results.

[0041] Next, the thickness of the saturable absorption coloring matter contained layer produced the optical recording medium using the transparent substrate which is 170 nm. That is, the reflection film which consists of a vacuum evaporation film of aluminum was formed on the saturable absorption pigment layer formed on the transparent substrate. Under the present circumstances, it vapor-deposited by the very general method using EVD-500A by Japanese ** Anelva CORP. on degree-of-vacuum 3×10^{-4} Pa and the conditions of about 2 nm/s of deposition rates as an evaporation apparatus. Thickness set to 400 nm and this performed measurement and a check in the thickness gage of the crystal oscillation.

[0042] And the reflectance of the above-mentioned optical recording medium was measured according to the optical system as shown in drawing 9. The above-mentioned optical system is constituted by the semiconductor laser (LD) 4 which is a source of regenerated light, the polarization beam splitter (PBS) 5 which divides regenerated light and catoptric light, the 1/4 wavelength plate (Qup) 6, and the focus lens 7. The regenerated light shown by the figure Nakaya seal L irradiated from the semiconductor laser (LD) 4 penetrates the polarization beam splitter (PBS) 5, the 1/4 wavelength plate (Qup) 6, and the focus lens 7, and is irradiated by the optical recording medium 8. The optical recording medium 8 glares, and as catoptric light shown by the figure Nakaya seal R, regenerated light penetrates the focus lens 7 and the 1/4 wavelength plate (Qup) 6, is divided by the polarization beam splitter (PBS) 5 from the regenerated light L, and is detected. The optical recording medium 8 is laid on the rotating disc which is not illustrated, and is made as it is pivotable. Rotational linear velocity of the optical recording medium 8 at this time was made into 1.5 – 4.5 m/s, and the output of the regenerated light at the time of irradiating with the wavelength of regenerated light 781 nm and the optical recording medium which are laser wavelength regions was measured by being referred to as 0.4 in NA of 1-10 mW and the focus lens 7.

[0043] As a result, the phenomenon which the reflected light intensity of the minimum part of the optical recording medium which is equivalent to the focal position of regenerated light increases was seen as the output of regenerated light rose. Under the present circumstances, there is no

change in regenerated light intensity, and it was checked that reflectance is rising.

[0044]The output of regenerated light and change of the reflectance in the focal position of regenerated light are shown in drawing 10. It was checked that reflectance is changing with change of the output of regenerated light. The output of regenerated light follows on changing to 0-10 mW, and reflectance is changing from 10% to 20%. It seems that this is based on the effect of the saturable absorption of a saturable absorption coloring matter contained layer.

[0045]The result of having asked for change of the reflectance at the time of changing the extinction coefficient of the saturable absorption coloring matter contained layer of such an optical recording medium by survey is shown in drawing 11. In the optical recording medium of this example of an experiment, it is checked that the extinction coefficient k of a saturable absorption coloring matter contained layer is 0.3, and when the extinction coefficient fell in 0.2 by the exposure of regenerated light in this optical recording medium from the result of drawing 11, it seems that reflectance improved from 10% to 20%. Therefore, it seems that change of the reflectance generated in the above optical recording media broke out since the complex index of refraction of this saturable absorption coloring matter contained layer changed with the effects of the saturable absorption of a saturable absorption coloring matter contained layer.

[0046]Example of an experiment In the example of 2 experiments, the detailed recording pattern below the diffraction limit of regenerated light was formed in the actual optical recording medium, and the experiment which reproduces this by super resolution was conducted. First, the sample was produced. In the usual optical recording medium, although the recording pattern is formed on the transparent substrate with the cycle of 1micrometer/bit, In the optical recording medium of this example of an experiment, the recording pattern was formed with the cycle of 0.3micrometer [bit], i.e., 0.6 micrometer, as an object for super resolution on the transparent substrate (glass 2P disc substrate 120 mm in diameter), and the saturable absorption coloring matter contained layer and the reflection film were formed one by one on this.

[0047]The above-mentioned saturable absorption coloring matter contained layer was formed on the transparent substrate with the spin coat method using PMMA using SINC like the example 2 of an experiment as a binder like the example 2 of an experiment as saturable absorption coloring matter, using cyclohexanone as a solvent. When mixing these, after carrying out heating stirring mixing of PMMA1.31g and 38.7 g of the cyclohexanone, 0.262g of SINC(s) were added and distributed heating mixing by an ultrasonic cleaner was performed. That is, the weight ratio of SINC and PMMA is set to 1:5. When applying on a transparent substrate with a spin coat method, it applied using the Mikasa, Inc spin coater at the number of rotations of 2000-2400 rpm of maximum engine speed. Then, in order to dry a solvent, it was neglected in the vacuum of 80 ** of ambient temperature for 2 hours.

[0048]Thus, the thickness of the obtained saturable absorption coloring matter contained layer was about 150 nm. The transmission spectrum of the substrate with which this saturable absorption coloring matter contained layer was formed is shown in drawing 12. As it was known seeing a figure, transmissivity in case the wavelength of irradiation light is 780 nm of a laser wavelength region was 30%.

[0049]Although the relation between the thickness of this saturable absorption coloring matter contained layer at the time of forming the above saturable absorption coloring matter contained layers on a flat glass substrate, transmissivity, and reflectance is shown in drawing 13, O in a figure shows the transmissivity of this saturable absorption coloring matter contained layer, the transmissivity of the medium reflectance, a figure middle point line, and whose solid line of - in a figure are complex-index-of-refraction 1.7-i0.45, and reflectance. The transmissivity of the medium which is complex-index-of-refraction 1.7-i0.45 shown as the result, figure middle point line, and solid line which are shown by O in a figure and -, and which were surveyed, and reflectance are well in agreement so that they may be known seeing these results, It is judged that the complex index of refraction of the surveyed saturable absorption coloring matter contained layer is 1.7-i0.45.

[0050]Subsequently, the Au film was formed with the vacuum deposition method as a reflection film on the saturable absorption coloring matter contained layer of 150 nm of thickness formed on the transparent substrate in which the recording pattern for super resolution was formed.

Using the vacuum deposition machine by a Showa vacuum company as a vacuum deposition machine, it was considered as degree-of-vacuum 3×10^{-4} Pa and the deposition rate of 0.4nm/s, and vapor-deposited by the very general method. The thickness of the reflection film was 80 nm.

[0051] Next, signal regeneration of the optical recording medium produced by doing in this way was performed. In the optical recording medium of this example of an experiment, a 0.3micrometer/bit signal is formed as a recording pattern for super resolution as mentioned above. Since this recording pattern is a signal more detailed than the diffraction limit of regenerated light, unless a super resolution phenomenon occurs, it is unrepeatable.

[0052] Then, rotational linear velocity of the optical recording medium was made into 3.7 m/s, the wavelength of regenerated light was 780 nm of a laser wavelength region, NA of the focus lens was set to 0.53, the output of regenerated light was changed to 1 mW - 10 mW, and the recording pattern was reproduced. the cutoff space cycle (2 NA/lambda) of Modulation TransferFunction (MTF) of this optical system is 0.74 micrometer -- the signal of 0.3micrometer [bit] /, i.e., the cycle of 0.6 micrometer, -- usually -- coming out -- it cannot read. As a result, when the output of regenerated light was 1 mW, some regenerative signal was acquired, and when the output of regenerated light was 2.5 mW, as shown in drawing 14, the signal with a frequency of 6 MHz was acquired by CNR=19.4dB. Then, although it reproduced similarly considering the rotational linear velocity of an optical recording medium as 10 m/s, when the output of regenerated light was 4 mW, the signal with a frequency of 6 MHz was acquired by CNR=18dB. It turned out that the above signal regeneration experiments have 1000 times or more of reproducibility, and the optical recording medium of this example of an experiment is stabilized dramatically.

[0053]

[Effect of the Invention] This invention the recording pattern recorded as unevenness or change of an optical property on the transparent substrate corresponding to the information signal. In the optical recording medium for detecting by change of the reflection of regenerated light which carries out vertical incidence from the transparent substrate side, and carries out a move scan relatively to a transparent substrate, and reproducing a signal. It has further a layer which contains saturable absorption coloring matter at least on a recording pattern, and the molar extinction coefficient epsilon in the wavelength of the regenerated light of said saturable absorption coloring matter is $10^4 \leq \epsilon$.

Since the relaxation time tau is 1 second $\leq \tau \leq 100$ ns, it is possible to take out the regenerated light of a spot diameter smaller than the diffraction limit of regenerated light, it is possible to reproduce the recording pattern by which minuteness making was carried out, and dealing with high-density-recording-ization enough is possible.

[0054] Without making a large change of a regenerated light study system, and a large change of an information storage method, this invention can raise storage density and can attain about 4 times [of the conventional optical recording medium] the storage density. It becomes possible to raise storage density substantially further according to concomitant use with the high-density-recording-ized art realized by change of a regenerated light study system or an information storage method, and the industrial value is dramatically high. The realization of the added type of a postscript and the optical recording medium of rewritable type which could apply also to the added type of a postscript which has a recordable layer, and the optical recording medium of rewritable type and whose storage density improved remarkably is also possible for this invention.

[0055] In this invention, the reflectance in a transparent substrate, a saturable absorption coloring matter contained layer, and an air interface may provide not less than 70% of reflection film one by one in such an optical recording medium. Consider it as the thickness which furthermore makes the approximately minimum reflected light intensity according the thickness of a saturable absorption coloring matter contained layer to interference to the light intensity of regenerated light, or let saturable absorption coloring matter be naphthalocyanine system

coloring matter.
Therefore, a still higher effect can be acquired.

[Translation done.]

* NOTICES *

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is a mimetic diagram showing a multilayer film system.

[Drawing 2] It is a sectional view showing the structure of an optical recording medium.

[Drawing 3] It is a figure showing an example of the beam profile of the reflectance distribution of the optical recording medium for which it asked by calculation and regenerated light, and catoptric light.

[Drawing 4] It is a figure showing other examples of the beam profile of the reflectance distribution of the optical recording medium for which it asked by calculation and regenerated light, and catoptric light.

[Drawing 5] It is a figure showing the example of further others of the beam profile of the reflectance distribution of the optical recording medium for which it asked by calculation and regenerated light, and catoptric light.

[Drawing 6] It is a figure showing the relation of the reflectance in the regenerated light output for which it asked by calculation, a catoptric light spot diameter, and the center of a spot of regenerated light.

[Drawing 7] It is a figure showing the relation between the reflectance in the center of a spot of regenerated light, and a catoptric light spot diameter.

[Drawing 8] It is a figure showing the transmissivity and reflectance to thickness of the saturable absorption coloring matter contained layer used in the example 2 of an experiment.

[Drawing 9] It is a mimetic diagram showing the optical system which measures the reflectance of an optical recording medium.

[Drawing 10] It is a figure showing the relation of change between the output of regenerated light, and the reflectance in the focal position of regenerated light.

[Drawing 11] It is a figure showing change of the reflectance at the time of changing the extinction coefficient of a saturable absorption coloring matter contained layer.

[Drawing 12] It is a figure showing the transmission spectrum of the substrate with which the saturable absorption coloring matter contained layer used in the example 3 of an experiment was formed.

[Drawing 13] It is a figure showing the relation between the thickness of the saturable absorption coloring matter contained layer used in the example 3 of an experiment, transmissivity, and reflectance.

[Drawing 14] It is a figure showing the regenerative signal of the optical recording medium used in the example 3 of an experiment.

[Description of Notations]

- 1 Transparent substrate
- 2 Saturable absorption coloring matter contained layer
- 3 Reflection film
- 4 Semiconductor laser (LD)
- 5 Polarization beam splitter (PBS)
- 6 1/4 wavelength plate (Qup)
- 7 Focus lens
- 8 Optical recording medium
- L Regenerated light
- R Catoptric light

[Translation done.]

* NOTICES *

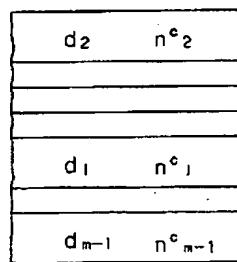
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DRAWINGS

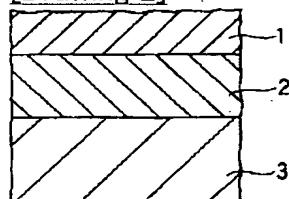
[Drawing 1]

再生光
↓ n^o_1

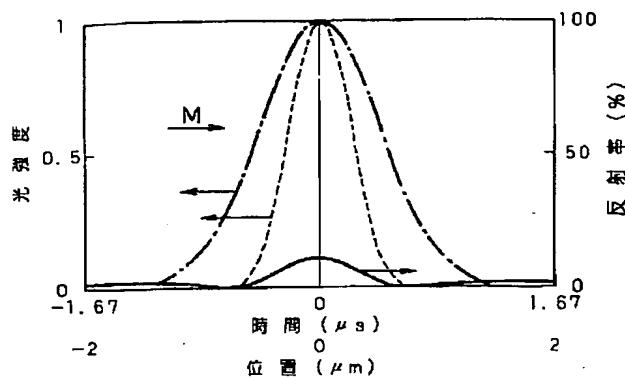


n^o_m

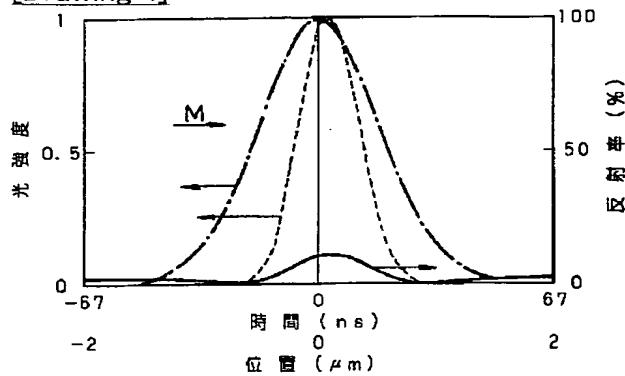
[Drawing 2]



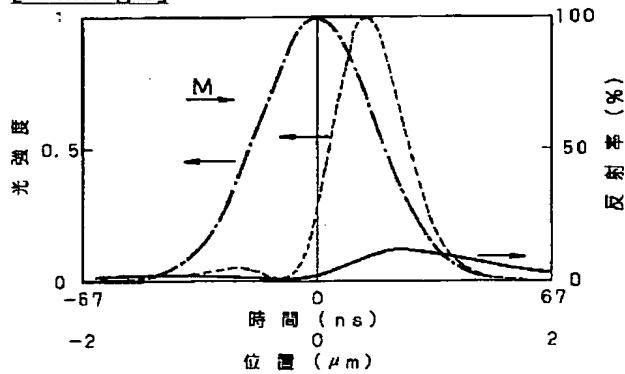
[Drawing 3]



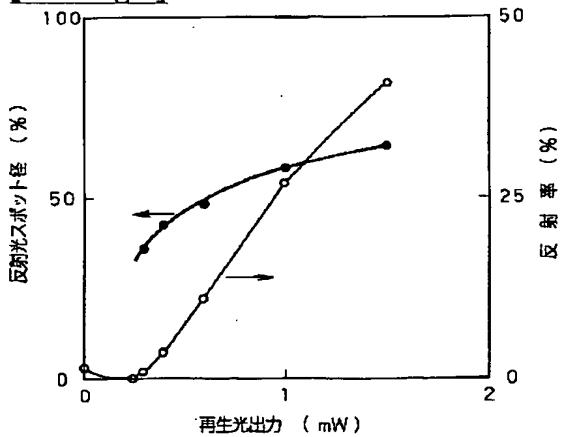
[Drawing 4]



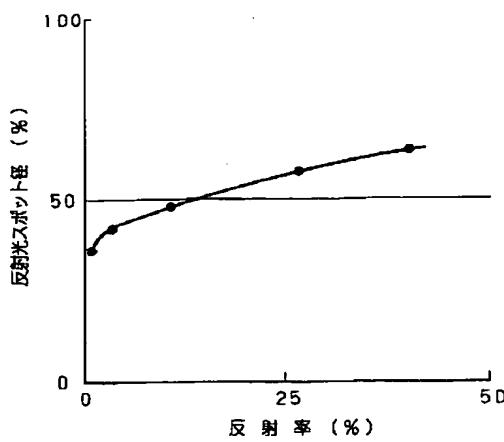
[Drawing 5]



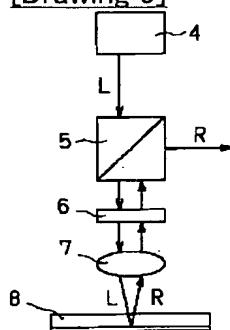
[Drawing 6]



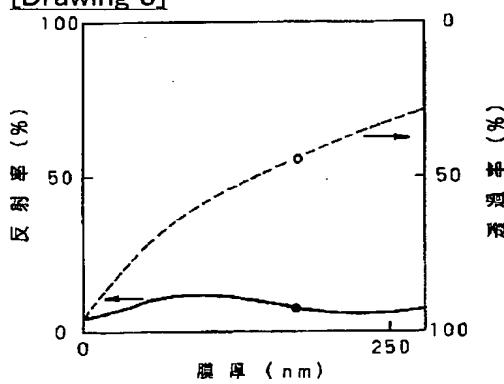
[Drawing 7]



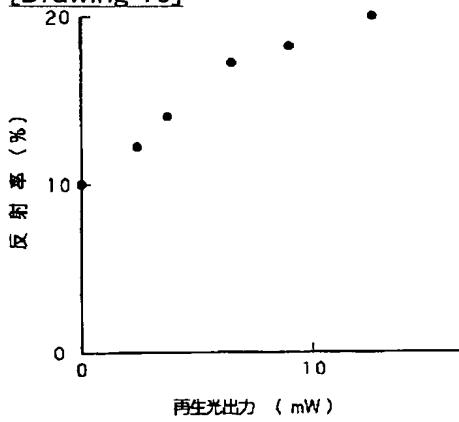
[Drawing 9]



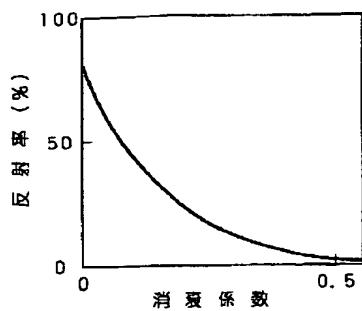
[Drawing 8]



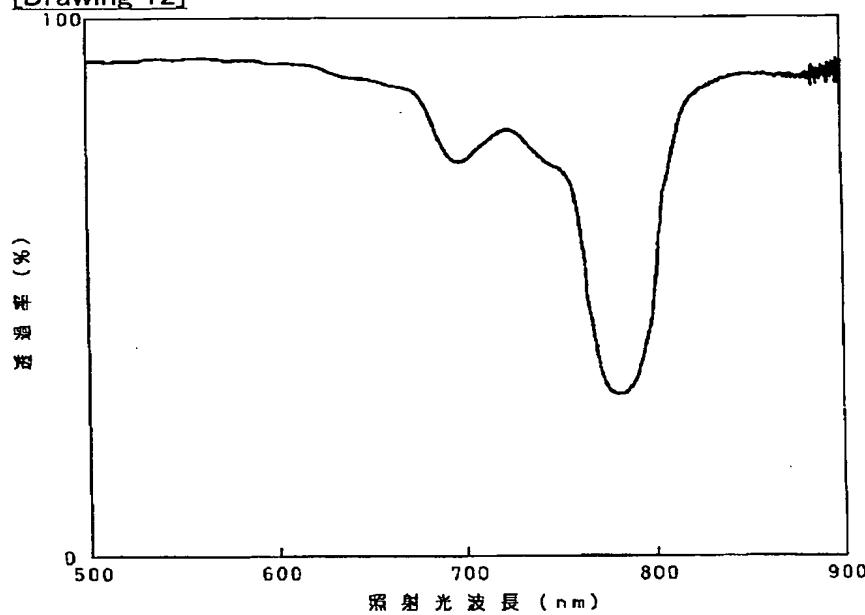
[Drawing 10]



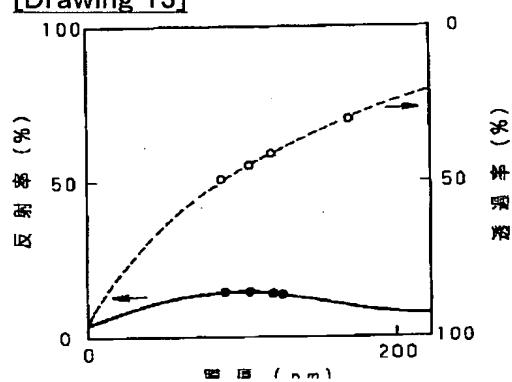
[Drawing 11]



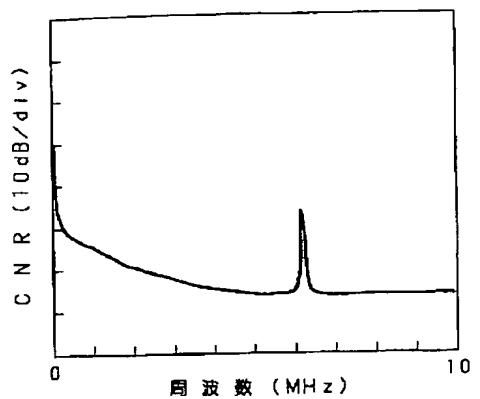
[Drawing 12]



[Drawing 13]



[Drawing 14]



[Translation done.]

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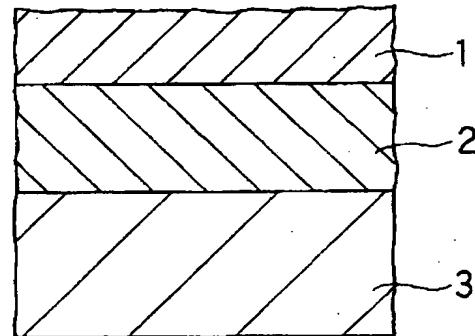
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(54)【発明の名称】 光記録媒体

(57)【要約】

【目的】 光記録媒体の記録密度を向上する。

【構成】 記録パターンの形成された透明基板1上の記録パターン形成面上に少なくとも可飽和吸収色素を含有する可飽和吸収色素含有層2を設け、該可飽和吸収色素の再生光の波長における分子吸光係数 ϵ を $10^4 \leq \epsilon$ とし、緩和時間 τ を $1\text{ns} \leq \tau \leq 100\text{ns}$ とする。また、上記可飽和吸収色素含有層2上に空気界面における反射率が70%以上の反射膜3を設けても良い。さらには、可飽和吸収色素含有層の厚さを再生光の光強度に対して干渉による反射光強度が極小となるようにしても良く、可飽和吸収色素をナフタロシアニン系色素としても良い。



【特許請求の範囲】

【請求項1】 透明基板上に情報信号に対応して凹凸や光学特性の変化として記録された記録パターンを、透明基板側から垂直入射し透明基板に対して相対的に移動走査する再生光の反射の変化で検出し、信号を再生するための光記録媒体において、

記録パターン上に少なくとも可飽和吸収色素を含有する層を一層有し、且つ該可飽和吸収色素の再生光の波長における分子吸光係数 ε が $10^4 \leq \varepsilon$ であり、緩和時間 τ が $1 \text{ n s} \leq \tau \leq 100 \text{ n s}$ であることを特徴とする光記録媒体。

【請求項2】 透明基板、可飽和吸収色素含有層及び空気界面における反射率が70%以上の反射膜が順次設けられていることを特徴とする請求項1記載の光記録媒体。

【請求項3】 可飽和吸収色素含有層の厚さが、再生光の光強度に対して干渉による反射光強度を略極小とする厚さであることを特徴とする請求項1記載の光記録媒体。

【請求項4】 可飽和吸収色素がナフタロシアニン系色素であることを特徴とする請求項1、2または3記載の光記録媒体。

【発明の詳細な説明】

【0001】

【産業上の利用分野】 本発明は、予め透明基板上に記録された情報信号に対応する凹凸や光学特性の変化による記録パターンを、基板側から再生光を照射して再生光ピームの反射の変化で検出して信号を再生するための光記録媒体に関するものである。

【0002】

【従来の技術】 近年、情報記録の分野においては光学情報記録方式に関する研究が各所で進められている。この光学情報記録方式は、非接触で記録・再生が行えること、磁気記録方式に比べて一桁以上も高い記録密度が達成できること、再生専用型、追記型、書換可能型のそれぞれのメモリー形態に対応できる等の数々の利点を有し、安価な大容量ファイルの実現を可能とする様式として産業用から民生用まで幅広い用途の考えられているものである。

【0003】 上述のメモリー形態のうち再生専用型の光記録媒体としては、デジタルオーディオディスク（いわゆる、コンパクトディスク）、光学式ビデオディスク（いわゆる、レーザーディスク）、あるいはCD-ROM等が既に広く普及している。これらの光記録媒体は、一般に、情報信号に対応した凹凸や光学特性の変化による記録パターンの形成された透明基板上にA1膜等の金属薄膜よりなる反射膜を形成した構造とされており、透明基板側よりレーザ光等の再生光を照射し、その反射光の強弱を検出して情報の再生を行う。

【0004】

【発明が解決しようとする課題】 上述のような再生専用型の光記録媒体においては、VTRのデジタル化、高精度度テレビジョン（HDTV）等に対応するために記録密度の更なる向上が求められている。また、操作上の都合から光記録媒体のサイズの小型化が求められており、このことからも記録密度の更なる向上が求められている。

【0005】 このような光記録媒体の記録密度を向上させる方法として光記録媒体に形成される情報に応じた記録パターンを微細化することが考えられるが、記録パターンをあまり微細化すると、これを再生する再生光のスポット径に回折限界があるため該記録パターンを再生できなくなってしまう。

【0006】 そこで、再生光の短波長化、信号コードの圧縮化、光学系の高NA化等の手段が検討されており、その中でも超解像は有力な手段として注目されている。

【0007】 上記超解像とは、物点位置に照射光の回折限界よりも小さなアーチャーを設けることにより、照射光のスポット径を回折限界よりも小さくして解像度を向上させることを原理とするものである。（参考文献：Charles W. McCutchen, "Superresolution in Microscopy and the Abbe Resolution Limit," J. of Optical Society of America, 57 (10), 1190 (1967). Tony Wilson and Colin Sheppard, "Theory and Practice of Scanning Optical Microscopy", Academic Press (London), 1984）

【0008】 このような超解像を光記録媒体に応用するには、再生光の光記録媒体上での移動に伴ってそのアーチャーが移動する必要がある。そこで、特開平2-96926に示されるように反射膜に光応答性の材料を使用する方法が提案されている。上記発明中においては、反射膜に光応答性の材料を使用することによって反射膜内に再生光の回折限界よりも小さなアーチャーを形成させ、反射膜によって反射される反射光のスポット径を小さくしてその解像度を向上させることが提案されており、光応答性の材料としては再生光によって直接的に光学特性が変化する非線形光学材料、或いは再生光の吸収による熱発生により光学特性の変化する相変化材料等が挙げられている。ところが、上記発明中にはこれに適する具体的な材料が例示されておらず、その具現性は低いものである。またこの特許に先立ち、特開平1-143041号公報、特開平1-143042号公報においては、光磁気記録再生方式において磁気カーラー効果が現れる領域を熱的に再生光のスポット径よりも狭くして超解像効果を発現させ、高密度記録再生を達成したことが報告されている。

【0009】そこで、本発明は再生光の回折限界よりも微細化された記録パターンによる高記録密度の情報を超解像によって再生することを可能とするための光記録媒体を提供することを目的とする。

【0010】

【課題を解決するための手段】上述の目的を達成するために本発明者等が鋭意検討した結果、光応答性の材料として可飽和吸収色素を用い、該可飽和吸収色素の光照射時における吸収飽和現象により超解像現象を実現できることを見出した。

【0011】すなわち、本発明は、透明基板上に情報信号に対応して凹凸や光学特性の変化として記録された記録パターンを、透明基板側から垂直入射し透明基板に対して相対的に移動走査する再生光の反射の変化で検出し、信号を再生するための光記録媒体において、記録パターン上に少なくとも可飽和吸収色素を含有する層を一層有し、且つ前記可飽和吸収色素の再生光の波長における分子吸光係数 ε が $10^4 \leq \varepsilon$ であり、緩和時間 τ が $1 \text{ ns} \leq \tau \leq 100 \text{ ns}$ であることを特徴とするものである。

【0012】また本発明は、このような光記録媒体において、透明基板、可飽和吸収色素含有層及び空気界面における反射率が70%以上の反射膜を順次設けても良く、さらに可飽和吸収色素含有層の厚さを再生光の光強度に対して干渉による反射光強度を略極小とする厚さとしてもよい。

【0013】さらにまた、本発明の光記録媒体においては、可飽和吸収色素をナフタロシアニン系色素としても良い。

【0014】本発明の光記録媒体においては、可飽和吸収色素含有層に再生光を照射して該可飽和吸収色素含有層の極小部分の複素屈折率を変化させることにより再生光の回折限界よりも小さいアーチャーを形成して、回折限界よりも小さいスポット径を有する反射光を得て、超解像現象を実現する。この際、可飽和吸収色素含有層中の可飽和吸収色素は再生光の吸収により基底状態から複素屈折率の変化した励起状態となり、アーチャーを形成し、緩和時間 τ を経て基底状態に戻る。従って、用いられる可飽和吸収色素の再生光の波長での分子吸光係数 ε が $\varepsilon < 10^4$ であると、可飽和吸収色素含有層の厚さを再生光の光強度に対して干渉による反射光強度を略極小とする厚さとした場合に十分な感度が得られない。また、可飽和吸収色素の再生光の波長での緩和時間 τ が $\tau < 1 \text{ ns}$ であると、アーチャー形成時間が短く十分な感度が得られず、 $100 \text{ ns} < \tau$ であるとアーチャー形成時間が長いためにアーチャーの形状が再生光の走査方向に長い楕円形となり、解像度を向上させることができない。なお、緩和時間 τ を $1 \text{ s} \sim 10 \text{ ns}$ とすることで、より高い効果が得られる。

【0015】また、可飽和吸収色素としては、再生光と

してレーザ光を用いることが多いことから、レーザ波長域 ($750 \sim 810 \text{ nm}$) に強い吸収を有するものが好ましく、さらには熱的、光化学的に安定なものが好ましい。このような可飽和吸収色素としては、シアニン系、フタロシアニン系、ナフタロシアニン系が挙げられ、例えば、EXCITON社製(アメリカ)のDTTC, HITC, IR-125, IR-140, IR-144等が挙げられる。特にナフタロシアニン系色素が大きな分子吸光係数、高い光学安定性を有するという点から好ましい。

【0016】

【作用】本発明は、透明基板上に情報信号に対応して凹凸や光学特性の変化として記録された記録パターンを、透明基板側から垂直入射し透明基板に対して相対的に移動走査する再生光の反射の変化で検出し、信号を再生するための光記録媒体において、記録パターン上に少なくとも可飽和吸収色素を含有する層を一層有し、且つ前記可飽和吸収色素の再生光の波長における分子吸光係数 ε が $10^4 \leq \varepsilon$ であり、緩和時間 τ が $1 \text{ ns} \leq \tau \leq 100 \text{ ns}$ であるため、再生光の回折限界よりも小さいスポット径の反射光を取り出すことが可能であり、再生光の回折限界よりも微細化された記録パターンを再生することが可能である。

【0017】

【実施例】以下、本発明を適用した具体的な実施例について実験結果に基づいて説明するが、実施例について述べるに先立ち、可飽和吸収現象による超解像効果について理論的説明をする。すなわち、透明基板上に可飽和吸収色素含有層、反射膜が順次形成される光記録媒体における可飽和吸収色素含有層の可飽和吸収現象を単純な速度方程式より求め、再生光の反射膜への透過率を算出し、再生光が光記録媒体上を移動している状態での光記録媒体としての反射率の分布、反射光のビームプロファイルを求めた。先ず、可飽和吸収色素含有層の可飽和吸収の速度方程式であるが、可飽和吸収色素が基底状態から光の吸収によって励起状態となり緩和時間 τ を経て基底状態に戻るものとし、単位面積 (cm^{-2}) で考えて、基底状態の分子数 G の変化は、全分子数 N 、吸収率 A 、再生光強度 I 、再生光波長 λ 、光速 c 、プランク定数 h として数1のようく表わされる。なお、上記可飽和色素は励起状態では光を全く吸収しないものとしている。

【0018】

【数1】

$$\frac{dG(t)}{dt} = -\frac{\lambda I A}{h c} + \frac{N-G(t)}{\tau}$$

【0019】この時、上記吸収率 A は、可飽和吸収色素含有層の消衰係数 k (複素屈折率虚数成分)、膜の構造や厚さ、光学定数によって決定される。なお、上記消衰係数 k は色素の分子数 G 、膜厚 d 、分子吸光係数 ε によ

って数2のようく表される。(数2中 N_A はアボガドロ数を表す。)

【0020】

【数2】

$$k = \frac{2.303 \varepsilon \lambda G}{4 \pi N_A d}$$

【0021】次に、上記吸収率Aと消衰係数kの関係を多層膜反射率計算により求めた。すなわち、図1に示すような多層膜系に於いて、これらの膜の構造、厚さ、複素屈折率により多層膜に対する正反射条件での計算式から求めた。上記多層膜に於いて、各層の膜厚を d_j 、複素屈折率を n^c_j ($= n_j - ik_j$)とした場合、反射率R、透過率T、吸収率Aはそれぞれ数3、数4、数5のようく表される。

【0022】

【数3】

$$R = \left| a_{21} / a_{11} \right|^2$$

$$* \quad \begin{bmatrix} a_{11}, a_{12} \\ a_{21}, a_{22} \end{bmatrix} = \begin{bmatrix} t_j^{-1}, s_j \\ s_j, t_j^{-1} \end{bmatrix} \prod_{j=2}^{n-1} \begin{bmatrix} t_j^{-1} \exp(i \delta_j), s_j \exp(i \delta_j) \\ s_j \exp(-i \delta_j), t_j^{-1} \exp(-i \delta_j) \end{bmatrix}$$

【0027】

※※【数7】

$$t_j^{-1} = (n^c_j + n^c_{j+1}) / 2 n^c_j$$

【0028】

★★【数8】

$$s_j = r_j / t_j = (n^c_j - n^c_{j+1}) / 2 n^c_j$$

【0029】

【数9】

$$\delta_j = 2 \pi n^c_j d_j / \lambda$$

【0030】このようにして吸収率Aと消衰係数kの関係を求めた。なお、可飽和吸収色素含有層内の基底状態の可飽和吸収色素の分子数が変われば、Kramers-Kroningの関係で複素屈折率の虚部だけでなく実部も変化するが、色素が希薄に分散されたものとして、今回の計算では実部屈折率の変化は無視した。

【0031】そこで、上述のような計算式を用いて実際の光記録媒体の反射率分布及び反射光のビームプロファイルを求めた。光記録媒体としては、図2に示されるようにガラスよりなる透明基板1上に可飽和吸収色素とバインダーよりなるよりなる可飽和吸収色素含有層2が形成され、その上にアルミニウムを蒸着してなる反射膜3の形成されたものを想定した。透明基板及び反射膜の複素屈折率をそれぞれ1.5-10, 1.9-17と想定した。また、可飽和色素含有層は、初期状態(再生光の出力が0)の時に反射率が0となる、或いは若干の出力

*【0023】

【数4】

$$T = \left| 1 / a_{11} \right|^2 (n_m / n_1)$$

【0024】

【数5】

$$A = 1 - R - T$$

【0025】この時、 $a_{11}, a_{12}, a_{21}, a_{22}, t_j^{-1}, s_j, \delta_j$ は、数6、数7、数8、数9のよう に表される。この時、 $a_{11}, a_{12}, a_{21}, a_{22}$ は、この多層膜系の伝搬マトリクスの各成分、 t_j は j と $j+1$ 番目の層間の界面での透過係数、 s_j は同界面での(反射係数/透過係数)、 δ_j は j 層の前後での光の位相ずれを示す。

【0026】

【数6】

※※【数7】

$$t_j^{-1} = (n^c_j + n^c_{j+1}) / 2 n^c_j$$

の再生光が照射された状態で再生光の光強度に対して干渉による反射光強度を略極小とする厚さ、つまり可飽和吸収色素含有層/透明基板界面からの反射光と可飽和吸収色素含有層/反射膜界面からの反射光の位相が180° ずれたものとなる厚さ、いわゆる無反射条件を満たすものとし、複素屈折率を1.7-10.5とし、膜厚を1nmと想定した。

【0032】上記のような光記録媒体において、可飽和吸収色素の分子吸光係数 ε を 5×10^5 、緩和時間 τ を5ns、光記録媒体の回転線速度 v を1.2m/s、再生光のスポット径を2μm、再生光としてレーザ光を想定してその波長を780nm、その出力を0.6mWとした場合の計算結果を図3に示す。この光記録媒体の初期反射率は1.4%であったが、上記のような再生光を照射すると再生光のスポット中央においては図中実線で示されるような反射率が10%にまで上昇することがわかった。また、図中点線で示される反射光のプロファイル、すなわち上記光記録媒体における再生光の反射膜への透過率は、図中一点鎖線で示される再生光のプロファイルと同様に図中矢印Mで示される光記録媒体走行方向

に対して前後対称な形状となっている。

【0033】次に、光記録媒体の回転線速度 v を30m/sとした場合の結果を図4に示すが、これも図3の結果と同様に、図中点線で示される反射光のプロファイルは、図中一点鎖線で示される再生光のプロファイルと同様に図中矢印Mで示される光記録媒体走行方向に対して前後対称な形状となっている。なお、図中一点鎖線で示される再生光のプロファイルと反射光のプロファイルのズレは、時間として2ns、長さとして0.06μmである。よって、上記のような光記録媒体においては、該光記録媒体の回転線速度が可飽和吸収色素含有層に形成されるアーチャーの形状に及ぼす影響は小さく、反射率、反射光のプロファイルに及ぼす影響は小さいことがわかった。

【0034】また、緩和時間 τ を100nsとした場合の結果を図5に示す。図中点線で示される反射光のプロファイルが図中矢印Mで示される光記録媒体走行方向に対して後方に15ns程度ずれる。このずれの量はほぼ緩和時間 τ に比例して増加する。従って、緩和時間 τ が反射率、反射光のプロファイルに大きな影響を及ぼすことがわかった。また、図中で示すように、センターからずれ前後でピーム形状が非対称になることは再生信号にジッターが増え、エラーレートの上昇を引き起す。

【0035】次いで、再生光の出力を変化させて計算を行い、再生光出力と反射光スポット径、再生光のスポット中央における反射率の関係を調査した。結果を図6に示す。なお、反射光スポット径は再生光スポット径に対する割合（反射光スポット径/再生光スポット径）で示す。図6に示されるように再生光出力を上昇させるにつれて図中○で示される反射率は上昇し、且つ図中●で示される反射光スポット径もサチュレーションにより大きくなることがわかった。

【0036】再生光のスポット中央における反射率と反射光スポット径の関係を図7に示すが、図7の結果から反射光スポット径を再生光スポット径の50%程度とするためには、すなわち再生光の回折限界の1/2のスポット径を有する反射光を得るには、再生光のスポット中央における反射率を10~15%とすることが好ましいことがわかった。

【0037】これら理論的解析結果は、色素の物性上、膜の層構成が理想的な場合における結果である。この理想条件は材料、作製条件の確立により達成できると思われるが、ここでは実際の光磁気記録媒体における超解像効果に不可欠な現象である再生光出力に対する反射率の変化を実験例1で、理想条件とはずれているが、明らかに超解像効果が発現し、信号が検出された実験を実験例2で示す。

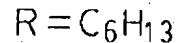
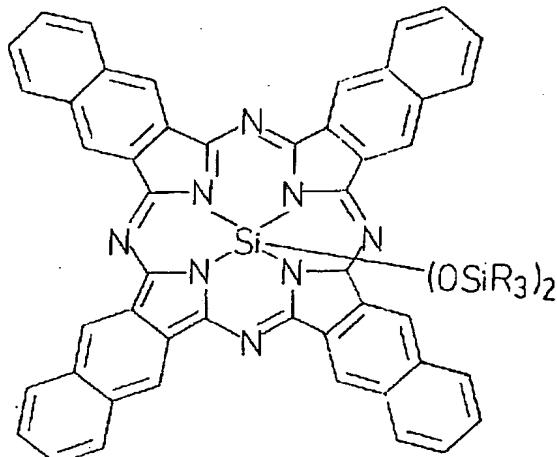
【0038】実験例 1

本実験例においては、実際に光記録媒体を製造し、該光記録媒体に再生光を照射した場合の反射率の変化の様子

を調査した。先ず、可飽和吸収色素含有層の複素屈折率の測定を行った。可飽和吸収色素として化1に示されるようなビス（トリ-n-ヘキシルシリコシ）ケイ素ナフタロシアニン（以後、S INCと称する。）を用い、バインダーとして分子量40万のポリメチルメタクリレート（以後、PMMAと称する。）を用い、これらをクロロホルムに溶解させ、透明基板であるガラス基板上にスピニコート法によって塗布し、膜厚を100~200nmまで変化させて可飽和吸収色素含有層を形成した。なお、S INCとPMMAとクロロホルムの混合比（重量比）は、2:15:500であり、これらの混合の際、PMMAは数時間にわたる攪拌と加熱を行い、S INCは超音波洗浄器による攪拌を行って完全に溶解させた。

【0039】

【化1】



【0040】このようにして得られた可飽和吸収色素含有層の透過率、反射率の測定を行った。結果を図8中に示す。なお、図中○は膜厚170nmの該可飽和吸収色素含有層の透過率、図中●は反射率、図中点線及び実線は複素屈折率1.7-10.3である媒体の透過率、反射率を示す。これらの結果を見てわかるように、図中○、●で示される実測された結果と図中実線、点線で示される複素屈折率1.7-10.3である媒体の透過率、反射率はよく一致しており、実測された可飽和吸収色素含有層の複素屈折率は、1.7-10.3であると判断される。

【0041】次に、可飽和吸収色素含有層の膜厚が170nmである透明基板を用いて光記録媒体の作製を行った。すなわち、透明基板上に形成された可飽和吸収色素層上にアルミニウムの蒸着膜よりなる反射膜を形成した。この際、蒸着装置として日電アネルバ社製のEVD-500Aを用い、真空度 3×10^{-4} Pa、蒸着レート2nm/s程度の条件で極一般的な方法で蒸着を行った。膜厚は400nmとし、これは水晶発振の膜厚計に

て測定、確認を行った。

【0042】そして、図9に示すような光学系により上記光記録媒体の反射率の測定を行った。上記光学系は、再生光源である半導体レーザ（LD）4、再生光と反射光を分割する偏光ビームスプリッタ（PBS）5、1/4波長板（QUP）6、フォーカスレンズ7によって構成される。半導体レーザ（LD）4より照射される図中矢印Lで示される再生光は、偏光ビームスプリッタ（PBS）5、1/4波長板（QUP）6、フォーカスレンズ7を透過して光記録媒体8に照射される。光記録媒体8に照射されて再生光は図中矢印Rで示される反射光として、フォーカスレンズ7、1/4波長板（QUP）6を透過し、偏光ビームスプリッタ（PBS）5により再生光Lより分割されて検出される。なお、光記録媒体8は図示しない回転円盤上に載置され、回転可能となされている。この時の光記録媒体8の回転線速度を1.5~4.5m/sとし、再生光の波長をレーザ波長域である781nm、光記録媒体に照射する際の再生光の出力を1~10mW、フォーカスレンズ7のNAを0.4として測定を行った。

【0043】その結果、再生光の出力が上昇するにつれて、再生光の焦点位置にあたる光記録媒体の極小部の反射光強度が増加する現象が見られた。この際、再生光強度には変化がなく、反射率が上昇していることが確認された。

【0044】図10に再生光の出力と再生光の焦点位置での反射率の変化を示す。再生光の出力の変化によって反射率が変化していることが確認された。また、再生光の出力が0~10mWに変化するに伴い、反射率は10%から20%へと変化している。これは可飽和吸収色素含有層の可飽和吸収の効果によるものと思われる。

【0045】また、このような光記録媒体の可飽和吸収色素含有層の消衰係数を変化させた場合の反射率の変化を実測により求めた結果を図11に示す。本実験例の光記録媒体においては、可飽和吸収色素含有層の消衰係数kが0.3であることが確認されており、図11の結果から該光記録媒体においては、再生光の照射によって消衰係数が0.2に下がったことにより反射率が10%から20%に向上したものと思われる。よって、上記のような光記録媒体において発生した反射率の変化は、可飽和吸収色素含有層の可飽和吸収の効果により該可飽和吸収色素含有層の複素屈折率が変化したために起きたものと思われる。

【0046】実験例 2

本実験例においては、実際の光記録媒体に再生光の回折限度以下の微細な記録パターンを形成し、これを超解像によって再生する実験を行った。先ず、試料の作製を行った。通常の光記録媒体においては、1μm/bitの周期で透明基板上に記録パターンが形成されているが、本実験例の光記録媒体においては超解像用として0.3

μm/bit、すなわち0.6μmの周期で透明基板（直径120mmのガラス2Pディスク基板）上に記録パターンを形成し、この上に可飽和吸収色素含有層、反射膜を順次形成した。

【0047】上記可飽和吸収色素含有層は、可飽和吸収色素として実験例2と同様にSINCを用い、バインダーとして実験例2と同様にPMMAを用い、溶剤としてシクロヘキサンを用いてスピンドル法により透明基板上に形成した。なお、これらを混合する際には、PMMA 1.31gとシクロヘキサン38.7gを加熱攪拌混合した後、SINCを0.262g添加して超音波洗浄器による分散加熱混合を行った。すなわち、SINCとPMMAの重量比は1:5となる。スピンドル法により透明基板上に塗布する際には、ミカサ社製のスピンドルコーターを用いて、最大回転数2000~2400rpmの回転数にて塗布を行った。その後、溶媒を乾燥させるために雰囲気温度80°Cの真空中に2時間放置した。

【0048】このようにして得られた可飽和吸収色素含有層の膜厚は150nm程度であった。また、この可飽和吸収色素含有層の形成された基板の透過スペクトルを図12に示す。図を見てわかるように、照射光の波長がレーザ波長域の780nmである時の透過率は30%であった。

【0049】また、上記のような可飽和吸収色素含有層を平坦なガラス基板上に形成した場合の該可飽和吸収色素含有層の膜厚と透過率及び反射率の関係を図13に示すが、図中○は該可飽和吸収色素含有層の透過率、図中●は反射率、図中点線及び実線は複素屈折率1.7-10.45である媒体の透過率、反射率を示す。これらの結果を見てわかるように、図中○、●で示される実測された結果と図中点線、実線で示される複素屈折率1.7-10.45である媒体の透過率、反射率はよく一致しており、実測された可飽和吸収色素含有層の複素屈折率は、1.7-10.45であると判断される。

【0050】次いで、超解像用記録パターンの形成された透明基板上に形成される膜厚150nmの可飽和吸収色素含有層上に反射膜としてAu薄膜を真空蒸着法により形成した。真空蒸着器としては、昭和真空社製の真空蒸着器を用い、真空中3×10⁻⁴Pa、蒸着レート0.4nm/sとし、極一般的な方法により蒸着を行った。なお、反射膜の厚さは80nmであった。

【0051】次に、このようにして作製された光記録媒体の信号再生を行った。前述のように本実験例の光記録媒体においては、0.3μm/bitの信号が超解像用記録パターンとして形成されている。この記録パターンは再生光の回折限界よりも微細な信号であるため、超解像現象が発生しないと再生することが出来ない。

【0052】そこで、光記録媒体の回転線速度を3.7m/sとし、再生光の波長をレーザ波長域の780nm

とし、フォーカスレンズのNAを0.53として再生光の出力を1mW~10mWまで変化させて記録パターンの再生を行った。この光学系のModulation Transfer Function (MTF) のカットオフ空間周期 ($2NA/\lambda$) は $0.74\mu m$ であり、 $0.3\mu m/bit$ 、すなわち $0.6\mu m$ 周期の信号は通常では読み出せない。その結果、再生光の出力が1mWの時に、若干の再生信号が得られ、再生光の出力が2.5mWである時には、図14に示すように、周波数6MHzの信号がCNR=19.4dBで得られた。この後、光記録媒体の回転線速度を10m/sとして同様に再生を行ってみたが、再生光の出力が4mWである時に、周波数6MHzの信号がCNR=18dBで得られた。上記のような信号再生実験は1000回以上の再現性があり、本実験例の光記録媒体は非常に安定したものであることがわかった。

【0053】

【発明の効果】本発明は、透明基板上に情報信号に対応して凹凸や光学特性の変化として記録された記録パターンを、透明基板側から垂直入射し透明基板に対して相対的に移動走査する再生光の反射の変化で検出し、信号を再生するための光記録媒体において、記録パターン上に少なくとも可飽和吸収色素を含有する層を一層有し、且つ前記可飽和吸収色素の再生光の波長での分子吸光係数 ϵ が $10^4 \leq \epsilon$ であり、緩和時間 τ が $1\text{ns} \leq \tau \leq 100\text{ns}$ であるため、再生光の回折限界よりも小さいスポット径の再生光を取り出すことが可能であり、微細化された記録パターンを再生することが可能であり、高密度記録化に十分対応することが可能である。

【0054】また、本発明は再生光学系の大幅な変更、情報記録方式の大幅な変更を行うことなく、記録密度を向上させることができ可能であり、従来の光記録媒体の約4倍程度の記録密度を達成することが可能である。さらに、再生光学系や情報記録方式の変更により実現される高密度記録化技術との併用によりさらに記録密度を大幅に向上させることができ可能となり、その工業的価値は非常に高い。なお、本発明は、記録可能な層を有する追記型、書換可能型の光記録媒体にも適用可能であり、記録密度の著しく向上された追記型、書換可能型の光記録媒体の実現も可能である。

【0055】また本発明においては、このような光記録媒体において、透明基板、可飽和吸収色素含有層及び空気界面における反射率が70%以上の反射膜を順次設けても良く、さらに可飽和吸収色素含有層の厚さを再生光の光強度に対して干渉による反射光強度を略極小とする

厚さとする、或いは可飽和吸収色素をナフタロシアニン系色素とすることにより更に高い効果を得ることができる。

【図面の簡単な説明】

【図1】多層膜系を示す模式図である。

【図2】光記録媒体の構造を示す断面図である。

【図3】計算によって求めた光記録媒体の反射率分布及び再生光、反射光のビームプロファイルの一例を示す図である。

【図4】計算によって求めた光記録媒体の反射率分布及び再生光、反射光のビームプロファイルの他の例を示す図である。

【図5】計算によって求めた光記録媒体の反射率分布及び再生光、反射光のビームプロファイルのさらに他の例を示す図である。

【図6】計算によって求めた再生光出力と反射光スポット径、再生光のスポット中央における反射率の関係を示す図である。

【図7】再生光のスポット中央における反射率と反射光スポット径の関係を示す図である。

【図8】実験例2で用いた可飽和吸収色素含有層の膜厚に対する透過率及び反射率を示す図である。

【図9】光記録媒体の反射率の測定を行う光学系を示す模式図である。

【図10】再生光の出力と再生光の焦点位置での反射率の変化の関係を示す図である。

【図11】可飽和吸収色素含有層の消衰係数を変化させた場合の反射率の変化を示す図である。

【図12】実験例3で用いた可飽和吸収色素含有層の形成された基板の透過スペクトルを示す図である。

【図13】実験例3で用いた可飽和吸収色素含有層の膜厚と透過率及び反射率の関係を示す図である。

【図14】実験例3で用いた光記録媒体の再生信号を示す図である。

【符号の説明】

1 · · · · 透明基板

2 · · · · 可飽和吸収色素含有層

3 · · · · 反射膜

4 · · · · 半導体レーザ (LD)

40 5 · · · · 偏光ビームスプリッタ (PBS)

6 · · · · 1/4波長板 (Qup)

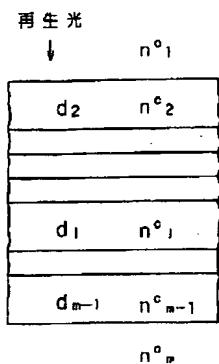
7 · · · · フォーカスレンズ

8 · · · · 光記録媒体

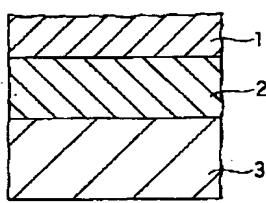
L · · · · 再生光

R · · · · 反射光

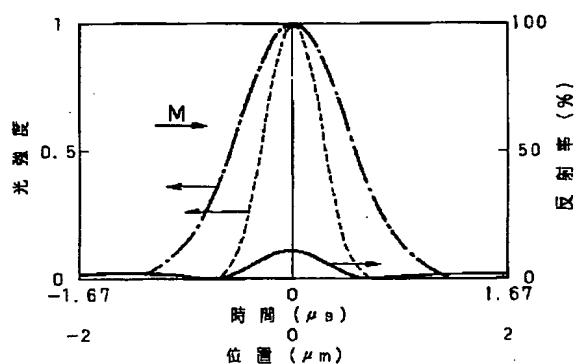
【図1】



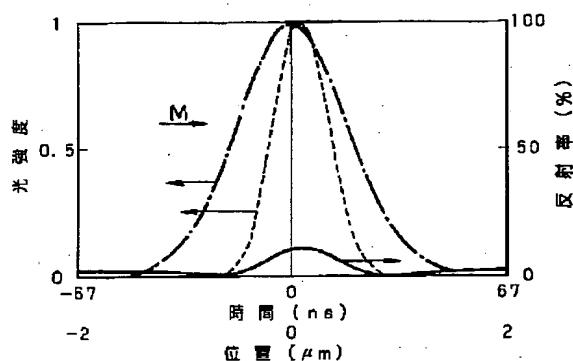
【図2】



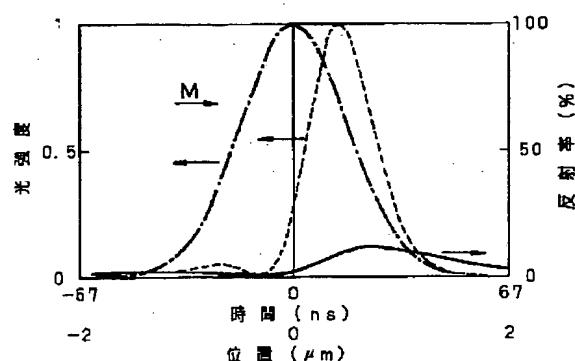
【図3】



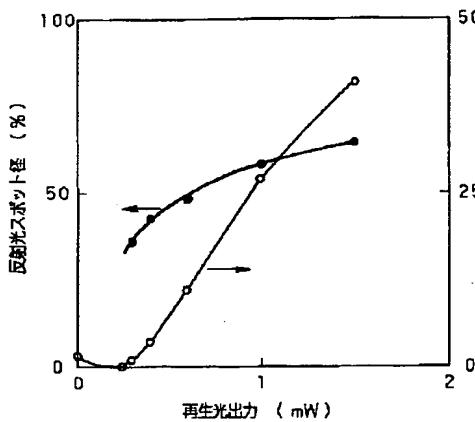
【図4】



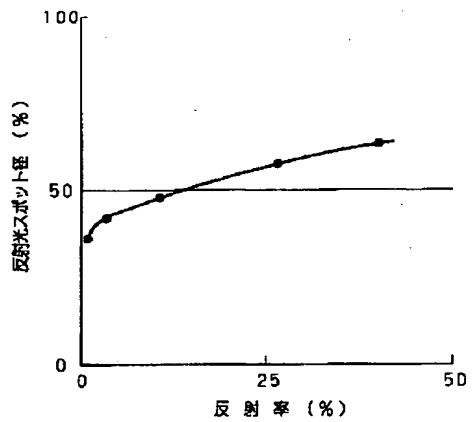
【図5】



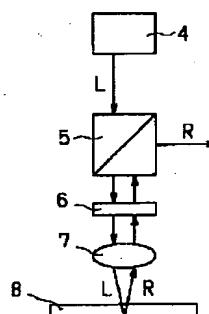
【図6】



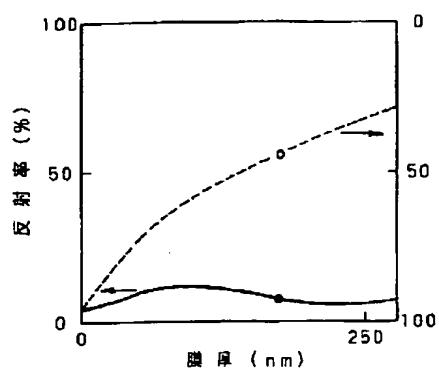
【図7】



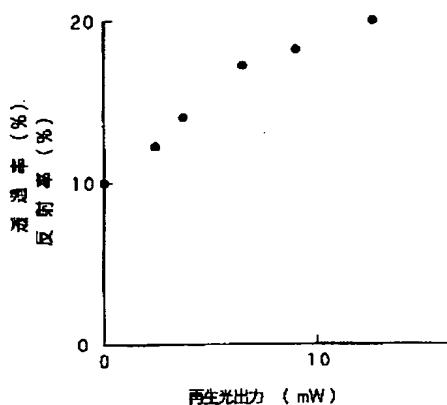
【図9】



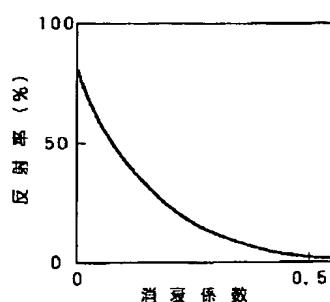
【図8】



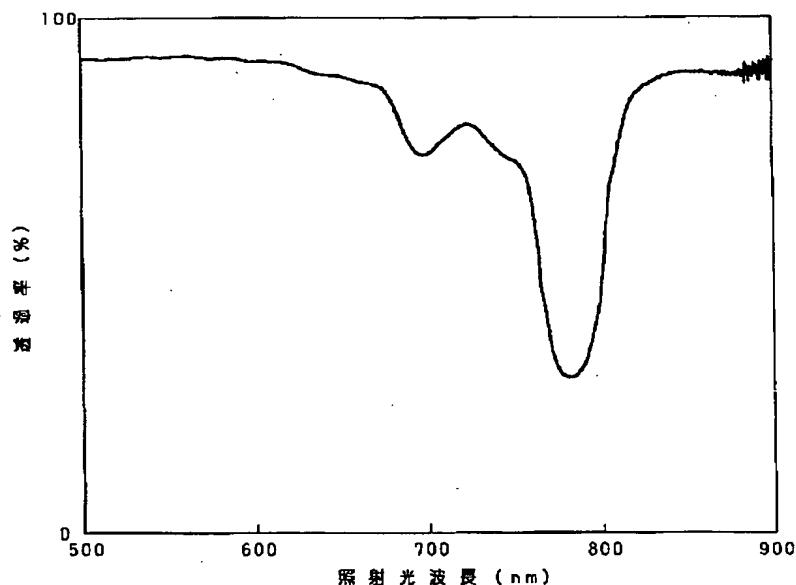
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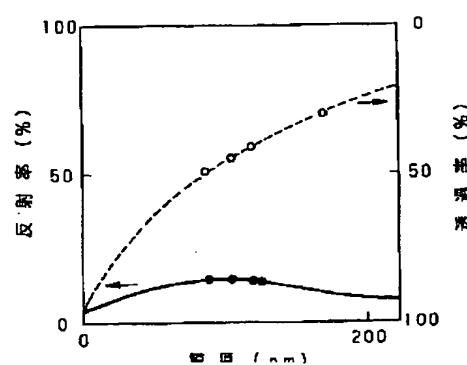
【図11】



【図12】



【図13】



【図14】

